

Hybrid analysis and modeling for next generation of digital twins

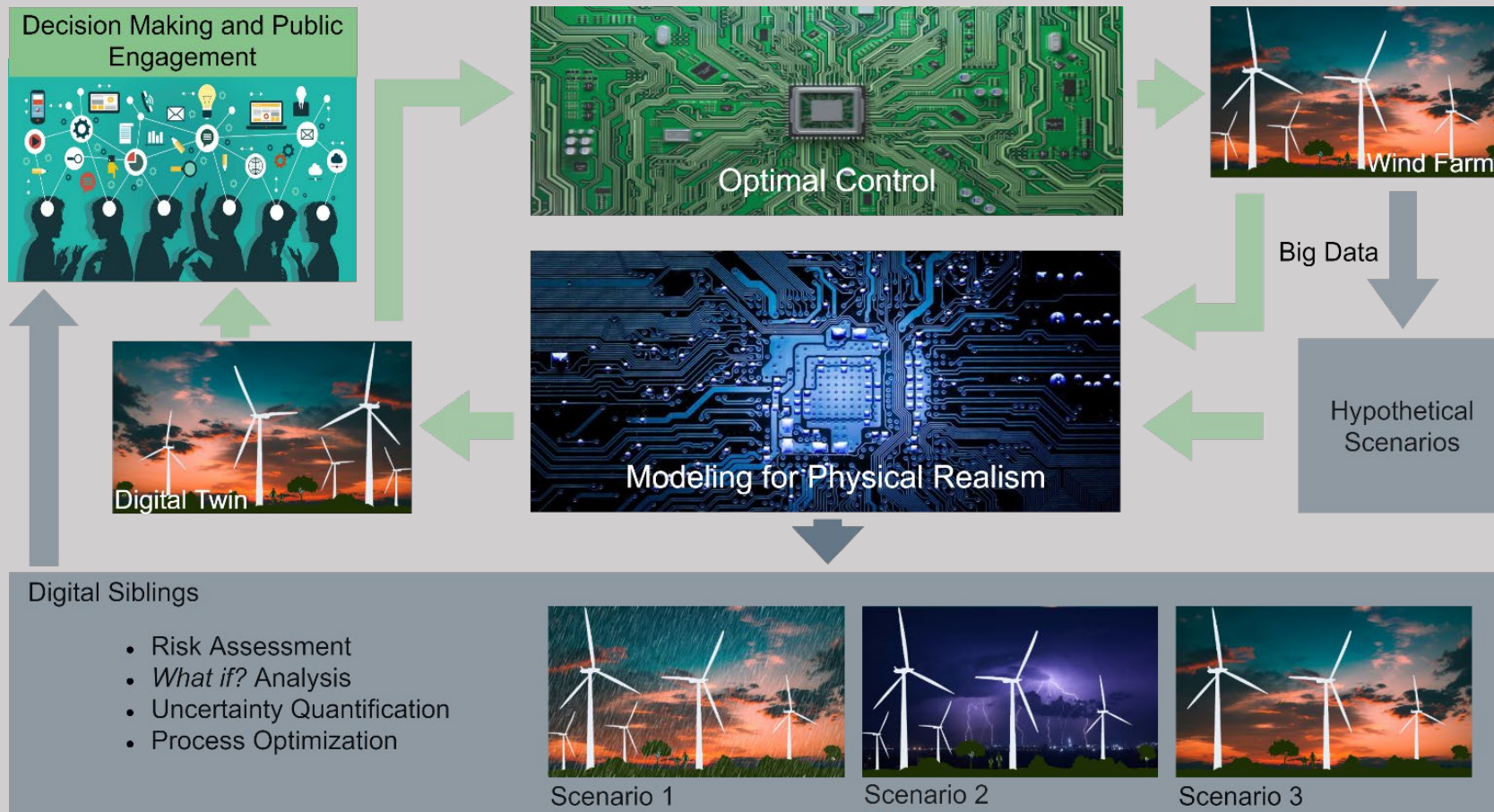
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Digital Twin



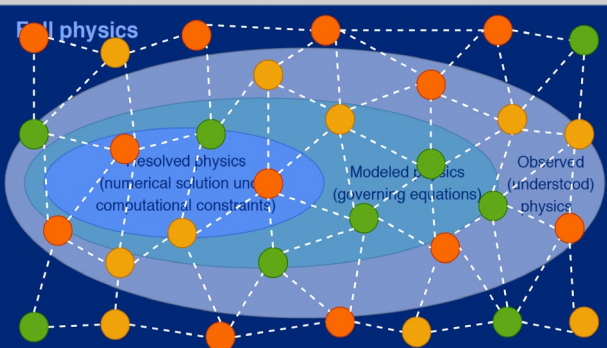
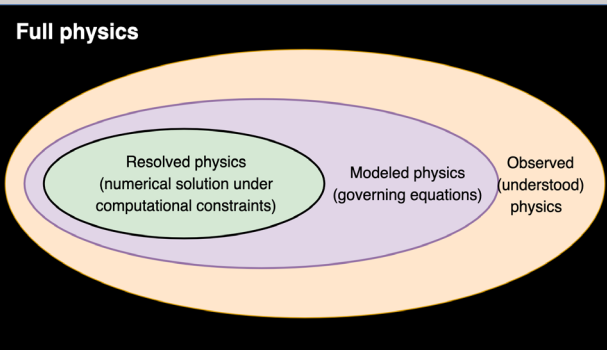
Requires models which are

- Computationally Efficient
- Trustworthy
- Accurate and certain
- Generalizable

Seamless integration

- Multiphysics
- Multiscale
- Multifidelity

State of the art



Physics based modeling

Solid foundation

Difficult to assimilate very long-term historical data into the computational models

Numerical instability

Uncertainties can be bounded and estimated

Less biased

Good generalization

Data driven modeling

Black box and discard even known physics

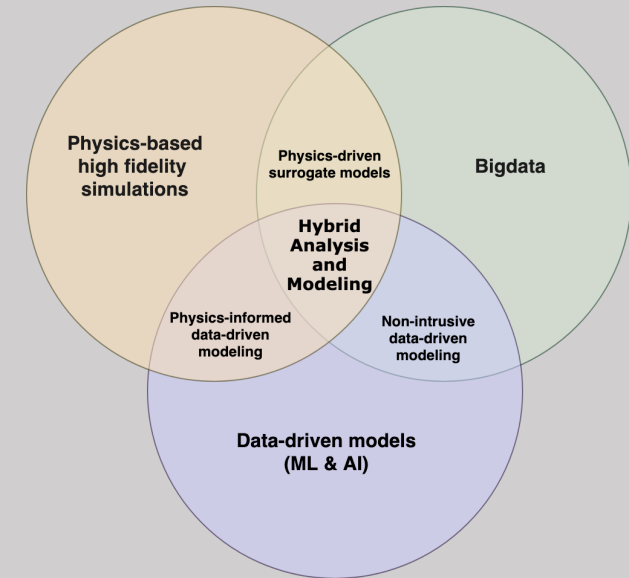
Takes into account long term historical data and experiences

Stable once trained

No such guarantee

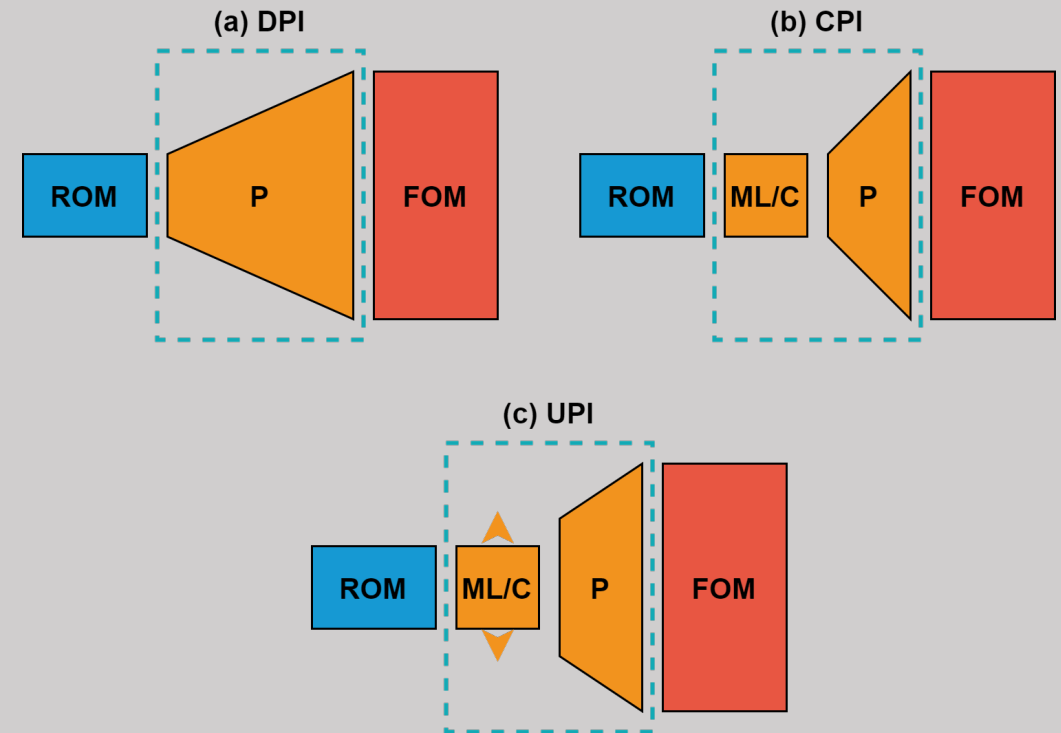
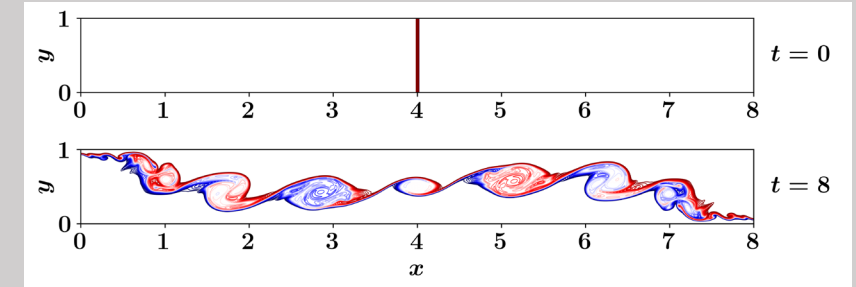
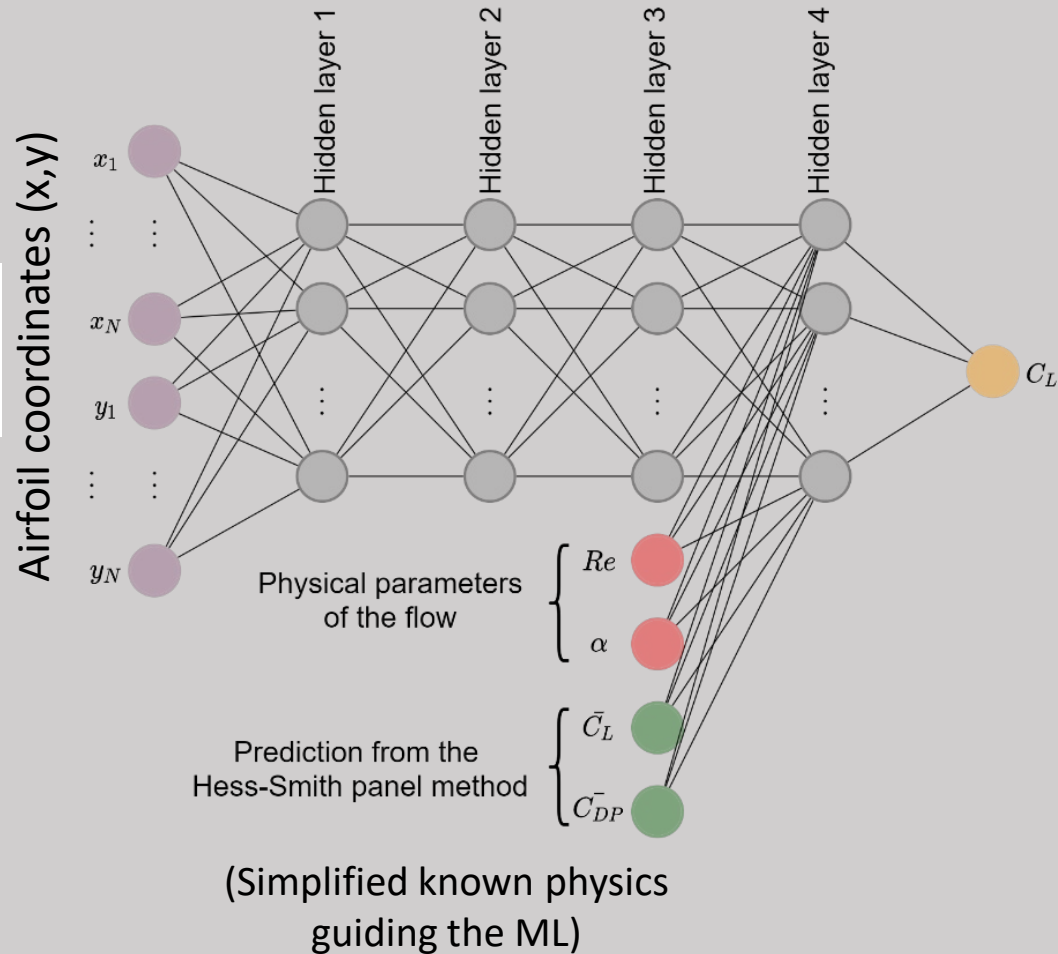
Biased

Poor generalization on unseen problems

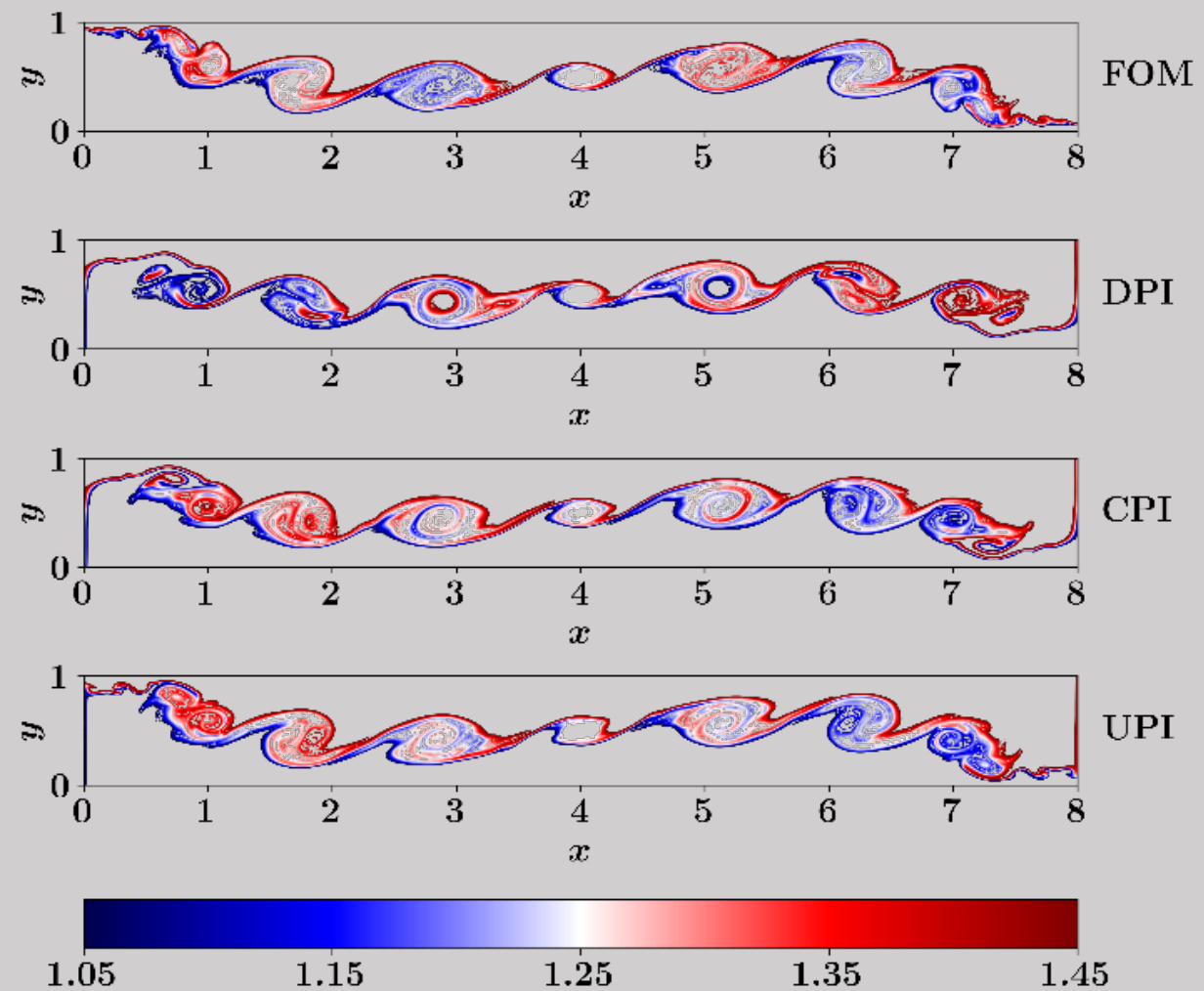
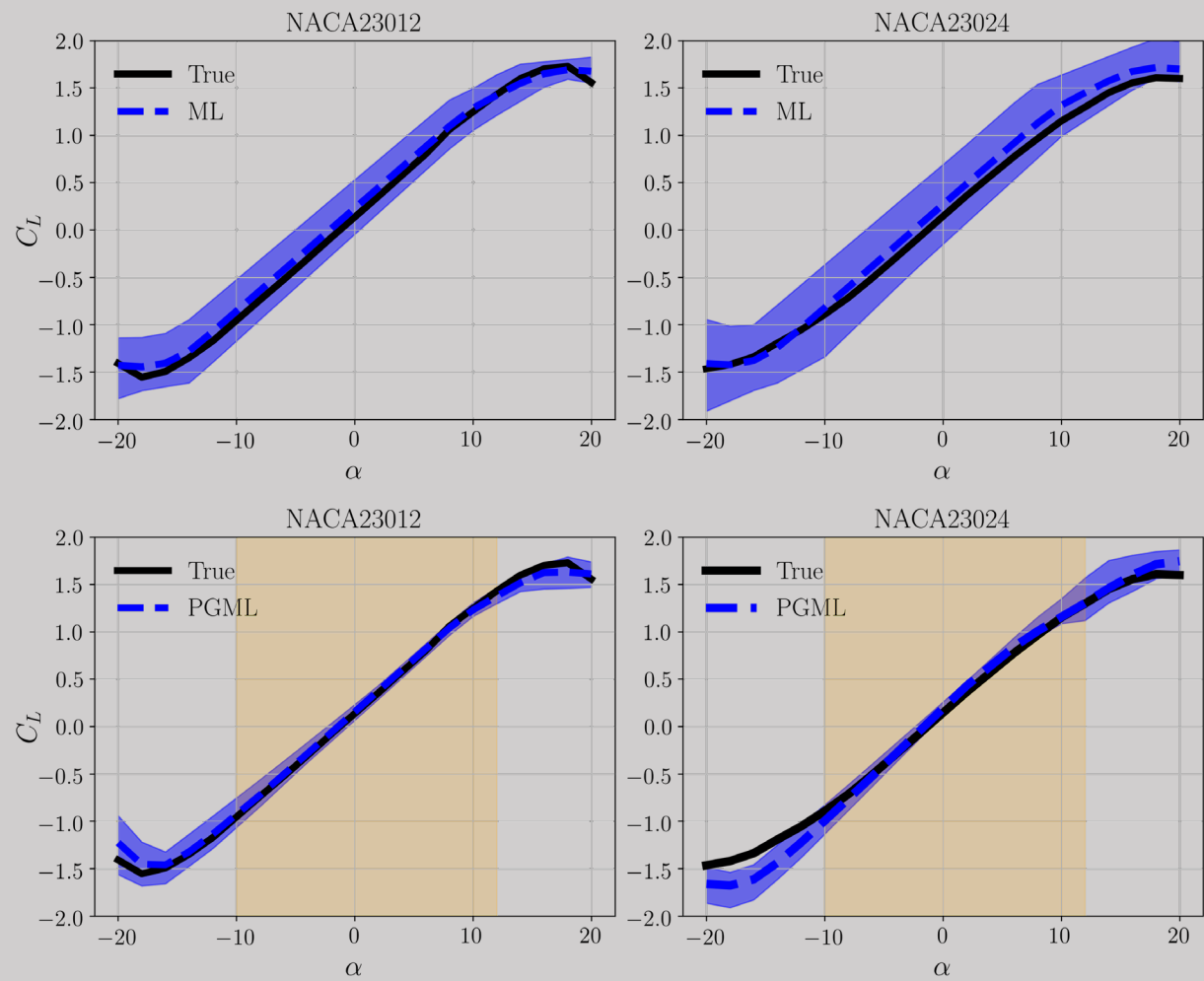


*HAM is a modeling approach that combines the **interpretability, robust foundation** and **understanding** of a **physics-based approach** with the **accuracy, efficiency**, and **automatic pattern-identification** capabilities of advanced **data-driven** machine learning and artificial intelligence algorithms to produce less uncertain results.*

HAM: 2 Proposed approaches



Results



Conclusion

- A novel Deep Learning architecture which enables injection of partially known physics leading to a more certain model 75% reduction in uncertainty for the smaller angle of attacks (i.e., -10° to 12°).
- A novel Interface Learning technique which elegantly couples multi-fidelity models leading to approximately 10x computational speed over the full order model.